ULTRASHORT PULSES IN MULTICOMPONENT MEDIA AND PHOTONIC BANDGAP STRUCTURES

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by

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13. ABSTRACT During the reporting period we have developed the mathematical algorithms and programs for the study of the resonant light-matter interactions in the multi-component and multilevel media and photonic bandgap structures. The optimal component distribution in the two-component media have been found to get a pulse of a superradiative emission of the highest intensity. The existence of the nonlinear solitary waves both in the Bragg and Laue geometry of diffraction has been shown in 2D- and 3D- periodical structures.			
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(1) The main goals of proposed research are:

Study of the specific features of ultrashort pulse propagation and dynamic nonlinear Bragg diffraction in two- and three-dimensional photonic bandgap structures;

Develop methods for the control of pulse duration and shape; and

Investigate coherent methods of ultrashort pulse formation, based on coherent interactions in multi-component media and photonic bandgap structures.

In accordance with the above mentioned goals during reporting period we have developed the mathematical algorithms for the study of the dynamics of superradiance by the multicomponent media. The developed algorithms enable us to determine the optimal component distribution to get the pulse of the highest intensity and shortest duration. We have started to study the dynamics of the bichromatic field propagation in the media of the three-level atoms or molecules. The selfsimilar solutions of this problem have been found in the form of the phasemodulated simulton and Raman solitons.

The specific features of the pulse propagation and amplification in the multicomponent media have been investigated. The results of the computer simulations enable us to find the new type of pulses with the stable pulse area. These pulses propagate in the two-component media in pairs. In dependent on the initial distance between pulses they propagate as a bound pair, colliding pulses or solitary pair. The dynamics of such pulse evolution is a demonstration of the new self-organizing processes in the resonant light-matter interactions.

The equations of nonlinear dynamic diffraction for general case of two-wave diffraction problem in 2D and 3D periodic resonant structures have been derived from the semiclassical Maxwell-Bloch equations describing the coherent light-matter interaction under Bragg condition. It has been created and tested the computer program to carry out the numerical simulation of nonlinear diffraction under different boundary conditions. By means of analytical integration of the equations we have investigated the process of propagation of Bragg solitary waves for the different geometric schemes of diffraction. It has been shown that nonlinear solitary waves appear both in the case of Bragg geometry of diffraction like gap two-wave solitons and in the case of Laue geometry of diffraction like two-wave solitons of nonlinear Borrmann effect. The "Laue soliton" propagates in the direction of the normal to reciprocal lattice vector.

It has been derived equations describing light-matter interaction in one-dimensional gain grating and in resonant periodic structures with a broad resonant layers. The computer program for numerical integration of the equations is created and tested.

(2) Brief statement of research plans for remainder of the contract period:

1. The investigation of the specific features of pulse amplification in the multi-component media and gain grating to define the optimal conditions for coherent pulse compression and amplification;

2. study of the characteristic properties of the coherent interactions in the three-level atomic media for the development of the methods of pulse parameter control;

3. exploration of the possibility for self-similar pulse formation during the process of the nonlinear diffraction in the excited photonic bandgap structures and gain grating;

4. the development of the mathematical algorithms and computations for the Maxwell-Bloch equations in the general case of ultrashort pulses to describe a pulse dynamics beyond the slowly varying envelope approximation.

(3) Prof. A.V.Andreev attended the Conference on photon echo and coherent spectroscopy (June 29- July 4, 1997, Kazan, Russia), where he made a talk on the problem related to the investigations supported by this contract and had a discussion with Prof. C.M.Bowden (U.S.Army Missile Command, Weapons Sciences Directorate Research, Development and Engineering Center, Redstone Arsenal, AL 35898-5248 USA).